

## **Design and Implementation of Gesture Controlled Robotic Arm for Industrial Applications**

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### **ABSTRACT**

Gesture means the movement of hand and face of humans. The main objective of this project is to control the robotic arm using human gestures. The human gestures are sensed with the help of an accelerometer, also known as inertial sensor. A microcontroller is used in the transmitter section. It is coded in such a way that the required actions for the human gesture are done. These sensed signals are processed and then transmitted to the robotic arm at the receiver section using RF transceiver module. Thus the robotic arm performs the required movement. A remote control system is also used to control the movement of the robot. This system is also uses an RF transceiver module for the wireless communication. The model can be constructed and the required work can be done. Thus, this proposed model will be helpful and avoid danger for the people working in hazardous areas.

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### **INTRODUCTION**

Robots are increasingly being integrated into industries to replace humans especially to perform the hazardous tasks. A robot is an electro-mechanical machine capable of carrying out a complex series of actions automatically or under human supervision. These are used in various fields such as industries, military, healthcare and research.

It might be dangerous for humans to perform some specific tasks like working with explosive chemicals, defusing bombs and other hazardous works. Therefore, humans can be replaced by robotic arm to perform the operations. A robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. The robot arms can be autonomous or controlled manually and can be used to perform a variety of tasks with great accuracy.

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Gesture recognition technology is used to control the robotic arm. Gesture recognition enables humans to communicate with the machine and interact naturally without any mechanical devices. Gesture recognition is a topic in computer science and language technology with the goal of interpreting human gestures via mathematical algorithms. Gestures can originate from any physical motion or state but commonly originate from the face or hand. Gesture recognition enables human to communicate with the machine and interact without any mechanical devices. Hand gestures are extensively used for robotic control applications and robotic systems can be controlled naturally and intuitively with such robotic communication.

## LITERATURE REVIEW

There are various ways in which a robotic arm may be controlled. In the past there have been many researchers working to control the robotic arm through computer terminals, joysticks, even interfacing them with the internet so that they can be controlled from anywhere in the world.

Accelerometer-based control of an industrial robotic arm technique was proposed by Pedro Neto *et al.*,<sup>[1]</sup>. It is operated using 3-axis wireless accelerometers, attached to the human arms, capturing its behavior (gestures and postures). When compared with other common input devices, especially the teach pendant, this approach using accelerometers is more intuitive and easy to work. It is also more reliable. It has a response time is 160 milliseconds. The future scope is the implementation of a gyroscope into the system.

Bonny Varghese *et al.*,<sup>[2]</sup> designed a wireless control of anthropomorphic robotic arm. It contains four movable fingers, each with three linkages, an opposing thumb with a rotating wrist and an elbow. The hand glove contains five linear slide potentiometers for controlling the finger movements and an accelerometer is also provided for the wrist and elbow movements. A dexterous anthropomorphic robotic arm with seven degrees of freedom has been designed. The use of this module limits the remote access of the robotic arm to a few meters.

K. Brahmani *et al.*,<sup>[3]</sup> used the technique of MEMS technology for controlling a robotic arm. It comprised of controlling of robotic arm powered with ARM7 based LPC1768 core. The LC1768 core was used and interfaced with DC motors of robotic arm to control their movements. MEMS, a three dimensional accelerometer sensor is used to capture the gestures of human-arm and produce three analog output voltages in three dimensional axes. Two flex sensors are also used to control the gripper movement using 2.4 GHz RF Module.

Malav Atul Doshi *et al.*,<sup>[4]</sup> proposed and analyzed the performance of a wireless robotic hand using flex sensors. The design and development of a robotic hand with real time control is precise and cost-effective. This five fingered robotic arm mimics a small degree of dexterity and is used for other applications such as prosthesis for leprosy patients. The robotic hand for tele-surgery using haptic technology was also implemented. But the major limiting factor was the time delay between the instructions.

Gourab Sen Gupta *et al.*,<sup>[5]</sup> proposed a Wi-Fi based control of a robotic arm with remote vision. The design of a controller intended for tele-operation is capable of controlling an anthropomorphic robotic arm through a LAN or via the internet. The user can control

the robotic arm remotely and access its sensory feedback signals as well. The camera mounted on the robot arm takes images and transmits to the control station. The robot arm was controlled using a master-slave control methodology. The system was operated using PC based hardware and a combination of the old and new master rig. The robotic arm movement is essentially instantaneous and simultaneous and the original rotation encoding method using potentiometers has been used.

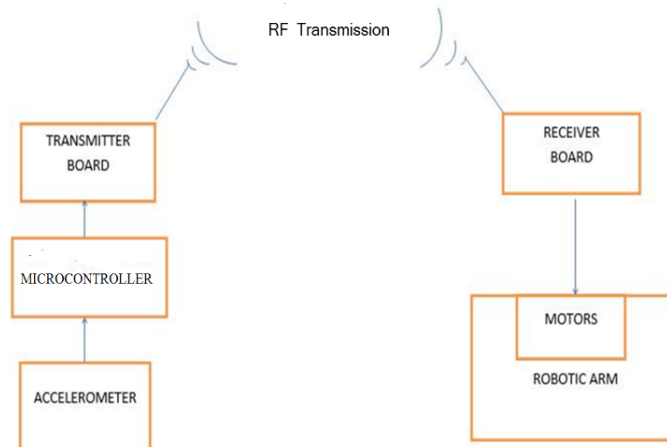
## SYSTEM OVERVIEW

This system mainly focuses on robotic arm model for safe guarding human using the concept of gesture controlled robots. This robotic system is divided into two modules.

### A. Gesture Recognition System:

The robotic arm is controlled by Gesture recognition system. Inertial sensors are used to recognize the human gestures and those actions are replicated by the robotic arm. The block diagram of Robotic arm is shown in Figure 1. This arm can be controlled from a long distance using RF module. The transmitter section consists of inertial sensors to sense the human gestures, Arduino Uno and RF transmitter module. The receiver section consists of RF receiver module, motor driver, relays and DC motors. Power supply of 12v is applied to both the sections. The Arduino Uno reads the analog output values from the accelerometer and converts the analog value to respective digital value. The digital values are processed by the Arduino Uno and send to the RF transmitter which is received by the Receiver and is processed at the receiver end which drives the motor to a particular direction.

**Figure – 1:** *Block Diagram of Gesture Recognition System*

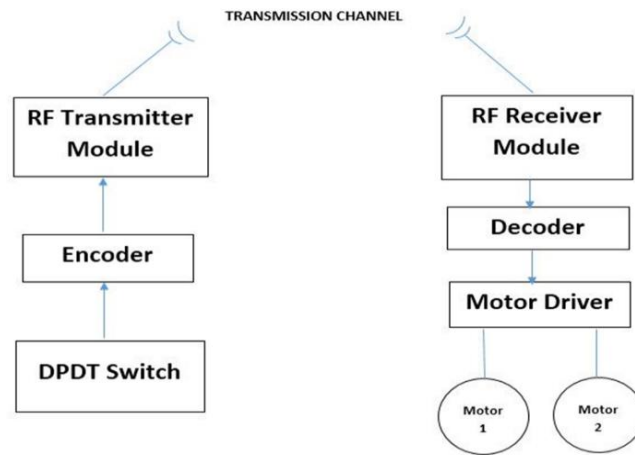


### B. Remote Control System

Wireless remote control system is used to control the mobility of the system. The switches are used to control the movements wirelessly using RF Module. This RF module consists of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF with its antenna connected at pin 4. The transmission occurs at the rate of 1Kbps to 10Kbps. The transmitted data is received by an RF receiver operating at

the same frequency as that of the transmitter. The RF module is used along with a pair of encoder and decoder. The encoder HT12E is used for encoding parallel data for transmission feed while reception is decoded by a decoder HT12D.

**Figure – 2:** *Block Diagram of Remote Control System*



### C. Camera & Sensors

Camera and temperature sensor are interfaced with Arduino Uno board to provide the additional feature to the system. Cameras are used for continuous video streaming so that the surrounding environment of the robot can be monitored. It is also used to view the work area which is not visible when it is operated from a distance. This video is streamed in a PC or a mobile by active internet connection. The temperature sensor is used to sense the surrounding temperature and prevent the system from damages.

## HARDWARE REQUIREMENTS

### A. Accelerometer

Accelerometer sensors are used to measure the tilt in x and y planes and convert it into analog signals. Accelerometers available today are small surface mount components, so it can easily have interfaced to a microcontroller. The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. It has 6 pins. First pin for power supply (VCC), second pin for ground (GND) and the last one for self-test (ST). Remaining 3 pins are for X, Y, Z axis. X and Y axis pins are connected to A0 and A1 pin of Arduino Uno board respectively. It operates on 3.3V from the Arduino Uno board. X and Y axis pins are connected to A0 and A1 pin of Arduino Uno board respectively. It can measure the static acceleration of gravity from tilt-sensing applications as well as dynamic acceleration resulting from motion, shock or vibration and gives corresponding analog values through X, Y, Z axis pins. The ADXL335 is available in a small, low profile, 4mm x 4mm x 1.45 mm, 16-lead, plastic lead frame chip scale package. The low cost and small size of 3-axis accelerometer are the two factor that makes it effective to detect the hand gesture.

### B. Arduino Uno

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz

quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Arduino consists of both a physical programmable circuit board and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. It is flexible, easy to use hardware and software. Arduino Uno can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators.

### C. RF Module

RF stands for radio frequency. It is available in different operating frequencies and with different operating range. We have used 433 MHz RF Tx/Rx module. RF module is often used along with a pair of encoder and decoder. It can transmit the signal up to 500 ft of range at rate of 1 Kbps to 10 Kbps.

Transmitter module consists of 4 pins (GROUND, VCC, DATA and ANTENNA). DATA pin is connected to encoder (pin 17). A 17 cm single strand wire antenna is used which is connected to antenna pin of Tx module. Transmitter receives serial data and transmits RF signal wirelessly to the receiver through this antenna.

Receiver module consists of 8 pins. 3 ground pins, 2 VCC pins, 2 DATA pins and 1 antenna pin. DATA pins are connected to decoder (pin 14). In this module also, a 17 cm single strand wire antenna is used for receiving RF signal from transmitter.

### D. HT12 Encoder and Decoder

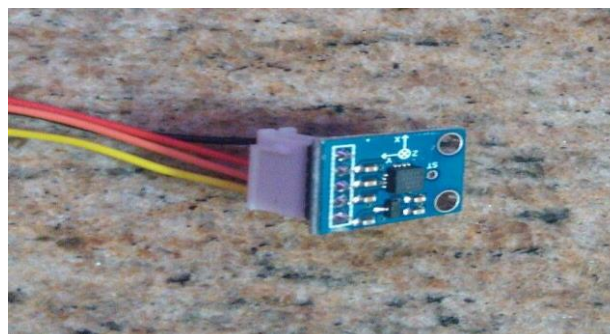
The HT12E encoder are 12 bit encoders that is they have 8 address bits and 4 data bits. It encodes the 12-bit parallel data into serial for transmission through an RF transmitter. Each of the address pins (A0 to A7) are connected to a switch.

HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by RF receiver into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously and is only decoded when no error or unmatched codes are found. A valid transmission is indicated by a high signal at VT pin.

## IMPLEMENTATION AND WORKING

The implementation process combines the robotic arm, remote control system, camera and sensors into a single system. The system has two controllers. Accelerometer sensor is used for arm control and Remote controller is used for the mobility of the device.

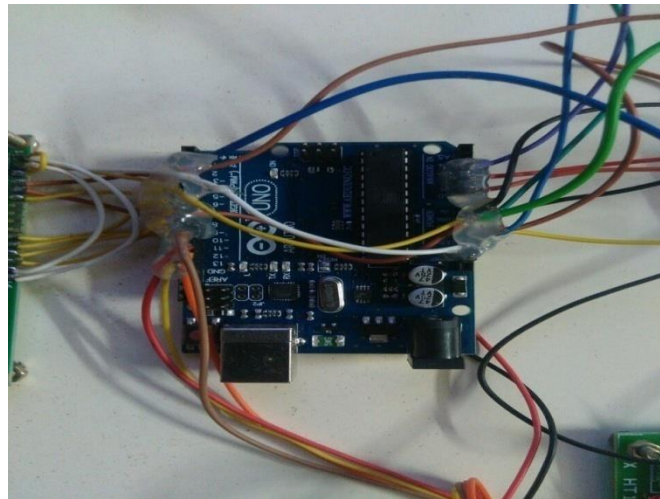
**Figure – 3:** *Accelerometer ADXL335*





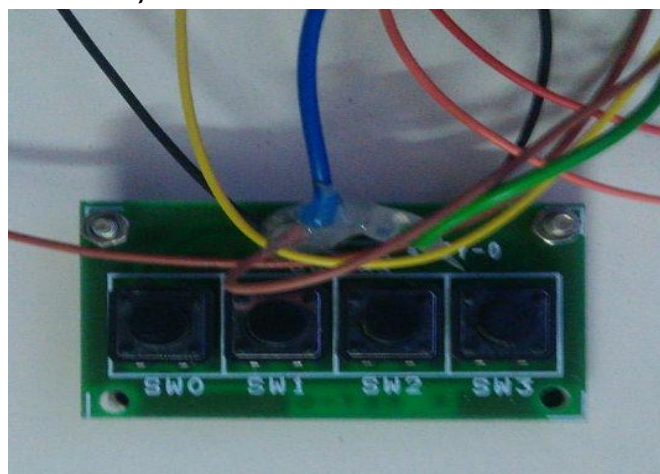
A 3-axis accelerometer mounted on the hand is used to capture human hand behaviors, and a microcontroller acquires the values in analog form. This analog data is converted into digital data and is transmitted using RF Module. The receiver section is the arm consisting of three DC motors which provide three degree of freedom to the arm. The motors are attached to the body of arm made of hollow metal and controlling circuitry is placed on a common base. One high torque DC is used for the horizontal motion with angles from -90 to +90 degrees and other is fixed in the base for the 360-degree rotation of the arm. The movement of gripper mouth is done by DC motor with angles of -90 to +90 degrees.

**Figure – 4:** *Arduino Uno connections*



The remote control system consists of two motors each controlled by respective wireless switches. The switches are connected to the address pins of the encoder HT12E. The encoder consists of Transit Enable (TE) pin that enables the transmission. So when the switch connected to pin 14 is pressed, the 8 address bits along with the 4 data bits (AD8 to AD11) are serially encoded and sent out at the DOUT pin.

**Figure – 5:** *Switch Connection for Remote Control*



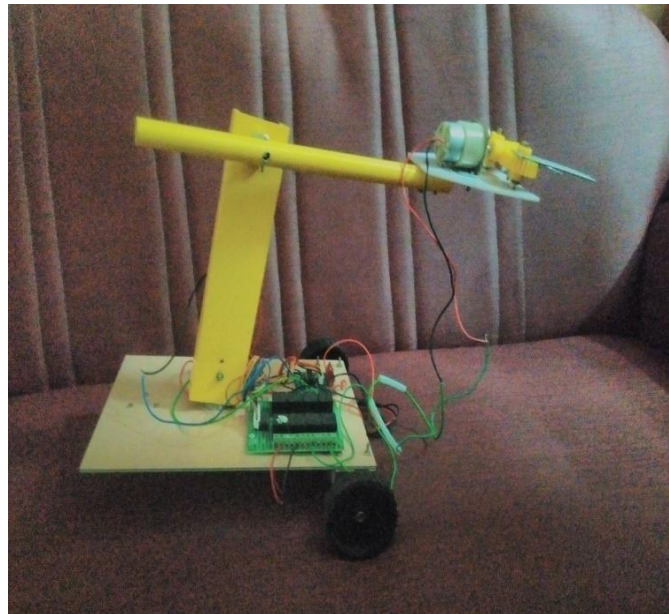
The data is received at the DIN pin from the RF receiver circuit and then this data is checked 3 times and then decoded and IC checks if the address pin connection of the encoder is same as that of the decoder. If the address configuration of the decoder matches

that in the received data (from encoder) the data is decoded and latched on to the data pins (D8 to D11). This decoded data is then send as control signals to the motor driver IC L293d. It is used to drive the motor in forward direction.

## RESULT

A mobile robotic system has been developed which works according to your hand gesture. It provides a better way to control a robotic arm using accelerometer which is more intuitive and easy to work. The RF module is working on the frequency of 433 MHz and has a range of 50-80 meters. This robot can be used in industries to perform hazardous tasks. It can also be upgraded to bomb detecting robot as it has robotic arm it can also lift the bomb. GPS system can be added to the robot by the help of which its location can be tracked.

**Figure – 6:** *Completed Robotic Model*



## CONCLUSION

The gesture controlled robotic arm for industrial application is designed and implemented. The movement is precise, accurate, as well easy to control and friendly to use. The robotic arm has been made very carefully and in a detailed manner so that the movement of the robot can be controlled accurately. This robotic arm control method will be helpful in many aspects to make human life comfortable and easy.

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